


Identifier: ER-SOP-7.05	Revision: 1	Effective Date: 02/08/2001	 environmental restoration project A Department of Energy Environmental Cleanup Program
ER Document Catalog Number: ER2001-0072			
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Environmental Restoration Project
Standard Operating Procedure

for:

Subsurface Moisture Measurements Using a Neutron Probe

Los Alamos

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Revision Log

<i>Revision (Date)</i>	<i>Prepared By</i>	<i>Description of Changes</i>	<i>Affected Pages</i>
0 (8/17/00)	John Hopkins	New Procedure	All
1 (2/xx/01)	Dennis Newell	This SOP was revised to reflect current sampling methods and to add a revision log page.	All

Subsurface Moisture Measurements Using a Neutron Probe

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Subsurface Moisture Measurements Using a Neutron Probe

NOTE: Subcontractors may follow this standard operating procedure (SOP) for providing instruction in the use of the neutron moisture probe or may use their own procedure(s) as long as the substitute meets the requirements prescribed by the Laboratory's LPR 308-00-00, Quality, and have been approved by the Environmental Restoration (ER) Project's Quality Program Project Leader (QPPL) before the commencement of the designated activities.

NOTE: ER Project personnel may produce paper copies of this procedure printed from the controlled-document electronic file located at <http://erinternal.lanl.gov/documents/Procedures/qps.htm>. However, it is their responsibility to ensure that they are trained to and utilizing the current version of this procedure. The author may be contacted if text is unclear.

1.0 PURPOSE

This standard operating procedure (SOP) describes the process of performing subsurface moisture measurements using a neutron moisture probe (CPN 503DR) within the vadose zone at the Los Alamos National Laboratory (Laboratory) for the ER Project. The *CPN 503DR Hydroprobe Moisture Gauge Operating Manual* (VM-6.00) also provides information on the theory of neutron-probe technology and generalized information on the calibration of the Hydroprobe. Troubleshooting methods and operating instructions that apply more generally to the use of this instrument under other circumstances and at other locations are beyond the scope of this procedure and are provided in the factory operating manual (VM-6.00). This SOP is a mandatory document and shall be implemented by all ER Project personnel when performing work in accordance with this QP

1.1 Lessons Learned

During the performance of work, ER Project personnel shall identify, document and submit lessons learned in accordance with QP-3.2, Lessons Learned. This QP can be located at:
<http://erinternal.lanl.gov/documents/Procedures/qps.htm>.

2.0 TRAINING

- 2.1 All users of this SOP are trained by reading the procedure and on the job training (as applicable), and the training is documented in accordance with QP-2.2.
- 2.2 Authorization to use the equipment described in this procedure requires Laboratory radiation worker training (I or II).

- 2.3 The **Field Team Leader** (FTL) will ensure that all field personnel who are assigned technical notebooks have read and implemented the requirements listed in QP-5.7 before documenting assigned tasks in any technical notebooks.
- 2.4 The **FTL** will monitor the proper implementation of this procedure and ensure that relevant team members have completed all applicable training assignments in accordance with QP-2.2.

3.0 DEFINITIONS

- 3.1 Moisture gauge, moisture probe, instrument, neutron probe — The entire instrument assembly.
- 3.2 Probe — The logging tool that contains the radioactive source and detector that is physically placed in the subsurface.
- 3.3 Surface assembly — The shielded casing that contains the instrument electronics and that houses the probe when not in use.
- 3.4 Cable — The depth-incremented cable that attaches the probe to the surface assembly.
- 3.5 Downhole — The position of the probe relative to the ground surface or surface casing. When the probe is physically placed into the subsurface, it is said to be downhole.
- 3.6 Authorized user (or operator) — A person who has successfully met the training requirements outlined in this SOP.
- 3.7 Logging technician — An authorized user who performs subsurface moisture logging using the moisture gauge.
- 3.8 Vadose zone — The unsaturated zone. Portion of the subsurface above the regional water table in which pores are not fully saturated.
- 3.9 Casing stick-up — The distance a borehole casing extends above the ground surface.
- 3.10 Site-Specific Health and Safety Plan (SSHASP) — A health and safety plan that is specific to a site or ER-related field activity that has been approved by an ER health and safety representative. This document contains information specific to the project including scope of work, relevant history, descriptions of hazards by activity associated with the project site(s), and techniques for exposure mitigation (e.g., personal protective equipment [PPE]) and hazard mitigation.

4.0 BACKGROUND AND PRECAUTIONS

Note: This SOP is to be used in conjunction with an approved SSHASP. Also, consult the SSHASP for information on and use of all PPE.

The neutron probe emits ionizing radiation from a sealed, registerable source. The neutron probe is subject to all source control requirements outlined in LIR402-716-01.1 *Radioactive Sealed Source Accountability/Control*

- 4.1 Exposure should be limited as follows:
 - When it is necessary to remove the probe from the housing for any reason, keep the probe as far away from the body as possible.
 - When the probe is unshielded by the surface assembly, minimize the length of time it spends on the surface.
 - Transport the instrument in its case by the handle.
 - When the probe is not downhole, require personnel not necessary to its operation to maintain a minimum distance of 10 ft.
 - In general, minimize both the number of persons in the vicinity of the probe and the time individuals spend near it.
- 4.2 Do not transport probes with any observed or suspected damage until source integrity has been verified by the Source Custodian and ESH-1.
- 4.3 Only authorized personnel may use the neutron probe. Authorization requires Laboratory radiation worker training (I or II) and on-the-job training to this procedure.
- 4.4 The moisture probe and cable are designed for use in vertical access holes. As designed, the instrument is placed over a borehole or access tube casing and the probe and cable are deployed directly from the surface assembly into the subsurface. When used in this way, the probe is not removed from the surface assembly or handled directly.
- 4.5 The moisture probe may also be used in angle holes and horizontal access holes. The use in these access holes will require the removal of the probe from the surface assembly for logging purposes. The deployment of the probe for logging may be possible using gravity if the access hole has a steep enough angle; however, for shallow angles and horizontal holes additional measure must be taken to successfully deploy the probe. These measures may include towing the probe with a cable or rope, deployment with rods, or deployment using positive pressure everting membranes. This procedure does not include instructions for deployment by means other than gravity.
- 4.6 The cable is marked in 1-ft increments, but the first mark on the cable indicates a depth of 2 ft. This marking assumes the probe and cable are

being deployed directly from the surface assembly and so takes into account the 1-ft height of the surface assembly itself.

- 4.7 When the probe is not deployed from the surface assembly, this correction to the probe depth is incorrect. The logging technician must add 1 ft to the depth indicated on the cable (e.g., if the cable increment reads 20 ft, record a depth to the probe of 21 ft). Similarly, the use of different cables may require different corrections to derive the correct depth of the probe from the surface.

5.0 EQUIPMENT

Suggested equipment and supplies needed to implement this procedure are listed below:

- 5.1 *Neutron probe (CPN 503DR)* — used to measure the subsurface moisture by use of a probe containing a source of high-energy neutrons and a slow neutron detector.
- 5.2 *Cable* — a depth incremented cable compatible with the CPN 503DR

6.0 PROCEDURE

Note: Deviations from SOPs are made in accordance with QP-4.2, Standard Operating Procedure Development and documented in accordance with QP-5.7, Notebook Documentation for Environmental Restoration Technical Activities.

This document provides instructions for using the CPN 503DR Hydroprobe to evaluate subsurface moisture content and specifies the requirements for the maintenance of this instrument. Using the Hydroprobe to measure moisture content consists of performing a daily field standard count, taking field measurements, and the proper documentation of the results.

6.1 Perform a Daily Field Standard Count

The standard count serves as an instrument check to ensure that the instrument source, detector, and electronics are operating within the manufacturer's specifications.

- 6.1.1 The **authorized user** (hereafter referred to as the **operator**) shall perform and document the daily field standard count at the beginning of each day of field measurements. To perform the daily field standard count:

1. Place the carrying case on the ground.
2. Verify that no other radioactive sources are within 30 ft.
3. Verify that no significant sources of hydrogen (e.g., people) are within 10 ft.
4. Remove the moisture probe from the carrying case.

5. Place the probe on the metal plate located on the lid of the carrying case.
6. Attach the cable to the probe.
7. Attach the cable to the surface assembly.
8. Ensure the display panel on the instrument reads "Ready"; if not, press "Clear".
9. Press "Std" on the instrument keypad; the instrument will display the stored current standard count.
10. Press "Step"; the instrument will display the stored previous standard count.
11. Press "Step" again; the instrument will display the "Xi" value for the stored standard count.
12. Press "Step" again; the instrument will display "NEW STD?"
13. Press "Enter," which is equivalent to "Yes."

Caution: Stand back at least 10 ft during the standard count.

The instrument will now collect 32 counts and average them. This is the standard count. When the count is complete, the instrument will display "S ####," where "####" is the standard count.

14. Press "Enter" to store the standard count.
15. Press "Step"; the previous standard count is displayed.
16. Press "Step" again; the current Xi value is displayed.

If...	Then...
the Xi value is not between 0.75 and 1.25,	repeat the process above.
the Xi value is between 0.75 and 1.25.	proceed to Step 17.
the instrument consistently returns Xi values outside of the acceptable range.	Do not use the instrument; the instrument requires servicing by the manufacturer.

17. Record the standard count, the previous standard count, and the Xi value in the logbook (see Section 6.3.1).

Note: Pressing "Clear" at any time during the standard counts will abort the standard count. "Clear" can be used to clear the instrument display and return to the "Ready" mode.

Note: A small black dot in a corner of the display panel indicates a low battery; the moisture probe should be recharged overnight before use.

6.2 Prepare Instrument for Field Measurements

This procedure assumes the **operator** will collect raw counts. Moisture content will be calculated in spreadsheets, which employ the applicable calibration. The instrument must be set to return raw counts as follows:

1. Press “Units” on the instrument keypad.
2. Press “Step” until the display reads “CNT”.
3. Press “Enter” on the instrument keypad; the instrument will return to the “Ready” mode.

6.3 Take a Field Measurement

The **operator** will take a field measurement in the following manner:

1. Lower the probe through the surface assembly with the cable to the desired depth.
2. Press “Start” on the instrument keypad; the instrument will count for 16 seconds.
3. At the “beep”, the instrument will display the value for that depth. Record the measurement in the logbook (see Section 6.4).
4. Repeat Steps 1 through 3 until all of the required measurements are complete.

6.4 Document the Results of the Field Measurement

6.4.1 The **FTL** will ensure that all field personnel who are assigned technical notebooks have read and implemented the requirements listed in QP-5.7 before documenting assigned tasks in any technical notebooks.

6.4.2 The **operator** records the data in a field logbook. At a minimum, the logbook will contain the following information:

- Field technician,
- date,
- location ID,
- standard count,
- previous standard count,
- Xi value,
- surface casing stick-up (if any),
- access hole diameter,
- casing type (e.g., PVC),
- casing depth,
- access hole total depth (below top of casing),
- and data with units identified (i.e., raw counts) vs. depth below top of casing.

6.4.3 When the logbook is no longer in use as a reference, the **FTL** will submit it to the Records Processing Facility (RPF) in accordance with QP-4.4.

7.0 REFERENCES

The following documents have been cited within this procedure:

LIR402-716-01.1, *Radioactive Sealed Source Accountability/Control*

QP-2.2, Personnel Orientation and Training

QP-4.2, Standard Operating Procedure Development

QP-4.4, Record Transmittal to the Records Processing Facility

QP-5.7, Notebook Documentation of Environmental Restoration Technical Activities

VM-6.00, CPN 503DR Hydroprobe Moisture Gauge Operating Manual

8.0 RECORDS

The **FTL** is responsible for submitting the following records (processed in accordance with QP-4.4, Record Transmittal to the Records Processing Facility) to the Records Processing Facility.

8.1 Completed field logbook forms

9.0 ATTACHMENTS

Attachment A: Field Logbook Entry form (1 page)

